Smoky Canyon Mine

Pilot Study Work Plan and Sampling and Analysis Plan

Biological Selenium Removal Treatment Technology Fluidized Bed Bioreactor

Final – September 2014

Addendum 03 – September 2015
Pilot Test Plan: Bioreactor Post Treatment with Oxidant
Frontier Water Systems (August 26, 2015)

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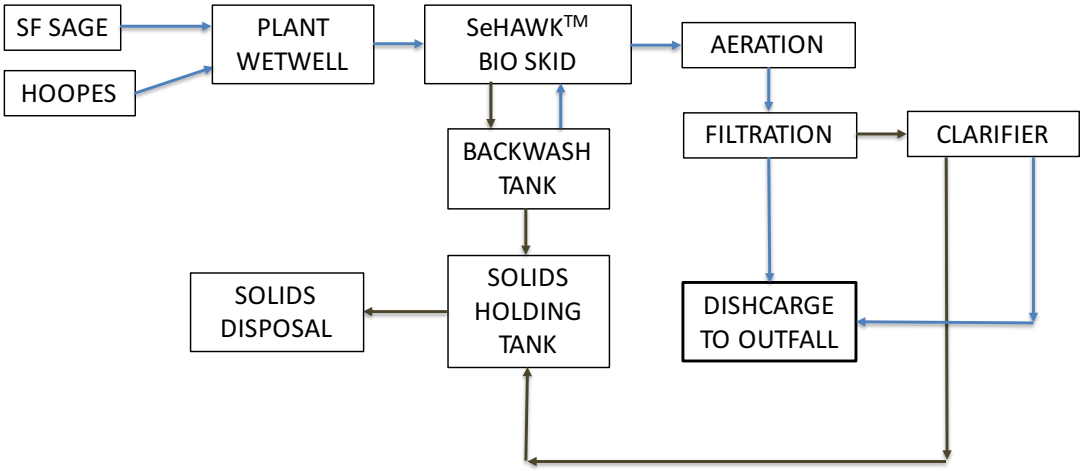
Pilot Test Plan: Bioreactor Post Treatment with Oxidant

Background:
The Frontier Water Selenium Removal System installed at the Hoopes Springs, Smoky Canyon Mine operates by creating anoxic, reducing conditions which will convert the soluble selenium (selenate) to elemental selenium. These insoluble selenium particles are then retained by the system and removed from the water stream. Some of the sulfate present in the water will also be subject to reduction to sulfide, which must be removed prior to discharge to the environment.

Following selenium removal, the water is subject to aeration to strip off any residual sulfide and add dissolved oxygen back to the water, The aeration step is effective in accomplishing both of these goals, but has been cultivating filamentous sulfide oxidizing bacteria, which have been identified as Thiothrix Type 1 bacteria. Thiothrix is problematic as it forms long filaments that impart a high solids load on the downstream sand filter, clogs the filter media, and attaches to rocks at the outfall. Further, the excess biomass load can impart an oxygen demand following the aeration, and create reducing conditions that can mobilize iron in the filter. A process flow schematic of the plant is provided below.

Selenium Treatment Plant Overview



Proposed Remedy:
Thiothrix and other sulfide oxidizing bacteria can be controlled by removing the sulfide from the stream prior to aeration. Sulfide can be removed by application of an oxidant treatment such as hydrogen peroxide or ozone.

In the scope of this pilot test, it is proposed to test oxidative treatment to remove sulfide directly from the selenium treatment plant effluent as it discharges to the aeration unit. This oxidative treatment will remove residual sulfide by converting it back to sulfate. It is proposed to use 27% hydrogen peroxide, which would be delivered directly to aeration tank, which is receiving the bioreactor effluent. Following the sulfide oxidation, residual peroxide will be consumed by the aeration unit, and the downstream sand filter.

Plant Modifications
The following equipment and modifications to the pilot plant will need to be implemented:

- Procure and install chemical feed skid for peroxide dosing
- Procure Hydrogen Peroxide feed tote (SDS attached)
- Install of peroxide injection point to aeration stage
- Install pH probe caustic injection point to bioreactor discharge
- Update PLC/HMI code to include pH control loop control integration for pH control and optimization
- Controls integration for chem feed system to include dose control/flow pacing

Test Plan
Hydrogen Peroxide solution will delivered prior to the aeration tank at a dose sufficient to oxidize any sulfide present in the bioreactor effluent. pH control with caustic will also be installed to raise pH (if required to meet effluent pH spec and/or to increase sulfur oxidation efficiency). Test duration will be 60 days and will include monitoring the parameters below.

Parameter	Location	Measurement
Sulfide	Aeration Tank	Field test, colorimetric
Peroxide	Post Aeration and Final Discharge point	Field test
Filter Performance	Reject Flow, Filter Headloss	On line
Dissolved Iron	Final Effluent	Field Test, colorimetric
Outfall aesthetics	Outfall	Visual Inspection

References

FWS- Simplot Microbial Analysis Report, Ramboll Environ,, August 2015

Safety Data Sheet, 27% Hydrogen Peroxide, US Peroxide.

Farquhar, G.J and W.C Boyle, Control of Thiothrix in Activated Sludge, Journal Water Pollution Control Federation, Vol. 44, No1, Jan 1972.